Update on IER 203 (Composite Reflectors):

Design for Successful Execution

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Overview

IER 203: BeRP Ball with Composite Reflector

Summary of the work required beyond CED-1 and 2 to prepare for an experiment that can be successfully executed.

- BeRP Ball
- Thin poly
- Thick Ni

- Pedestal raised into reflector monolith

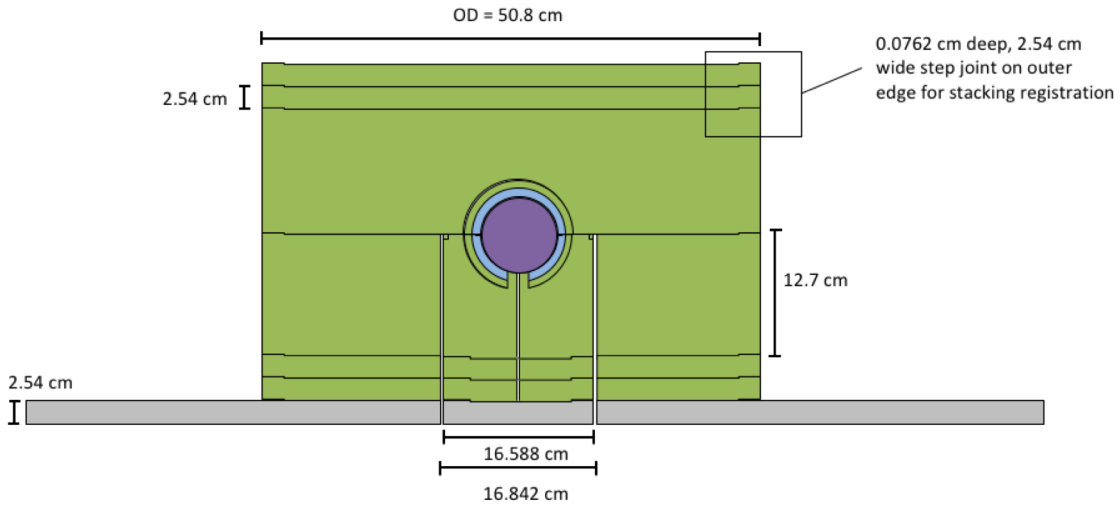


Figure from LLNL revised CED-2 addendum

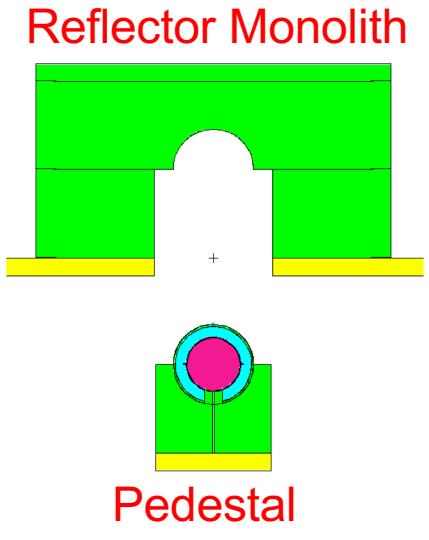
Focusing on using Planet for execution of IER 203

Planet

- Planet is a general-purpose vertical lift machine
- Consists of a stationary platform and a moveable platen.
- Most experiments rely on lower stack lifting upper stack slightly to ensure full contact.

Mechanical Design Challenges

- Close tolerance pedestal to monolith
- Pedestal goes into a blind hole

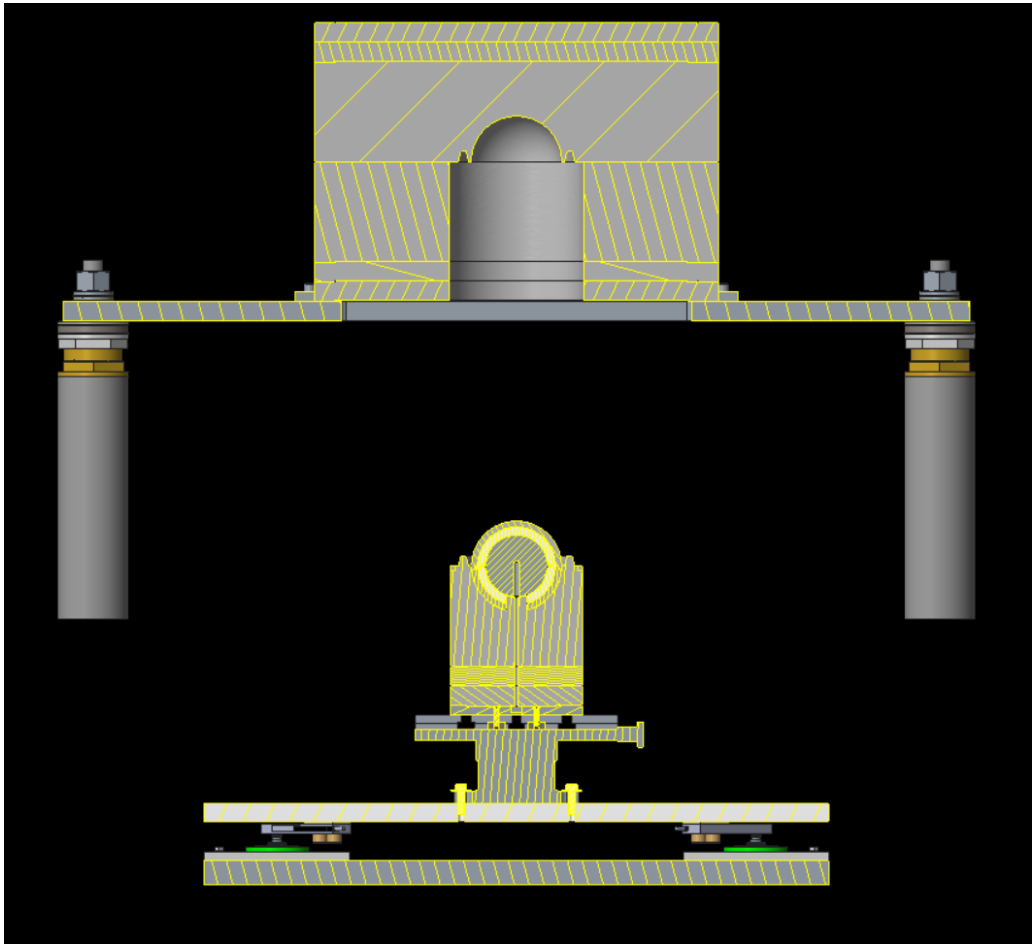


- Pedestal assembly must seat tightly in monolithic reflector
- No pressure allowed on BeRP ball

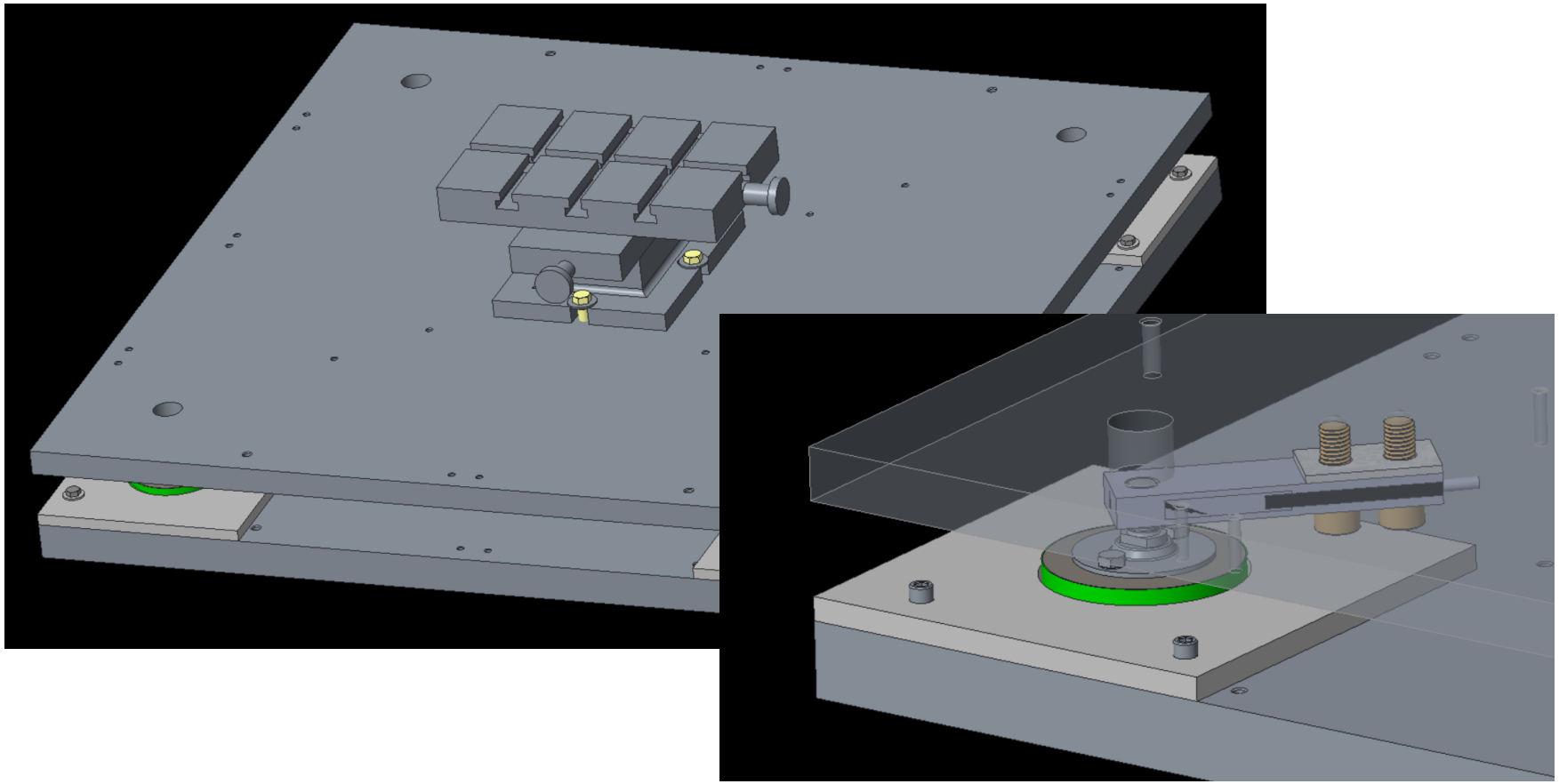
Figure from LLNL revised CED-2 addendum

- Must determine when pedestal is seated in reflector
- Space needed to load shells over BeRP ball with vacuum chuck

Cross Section View



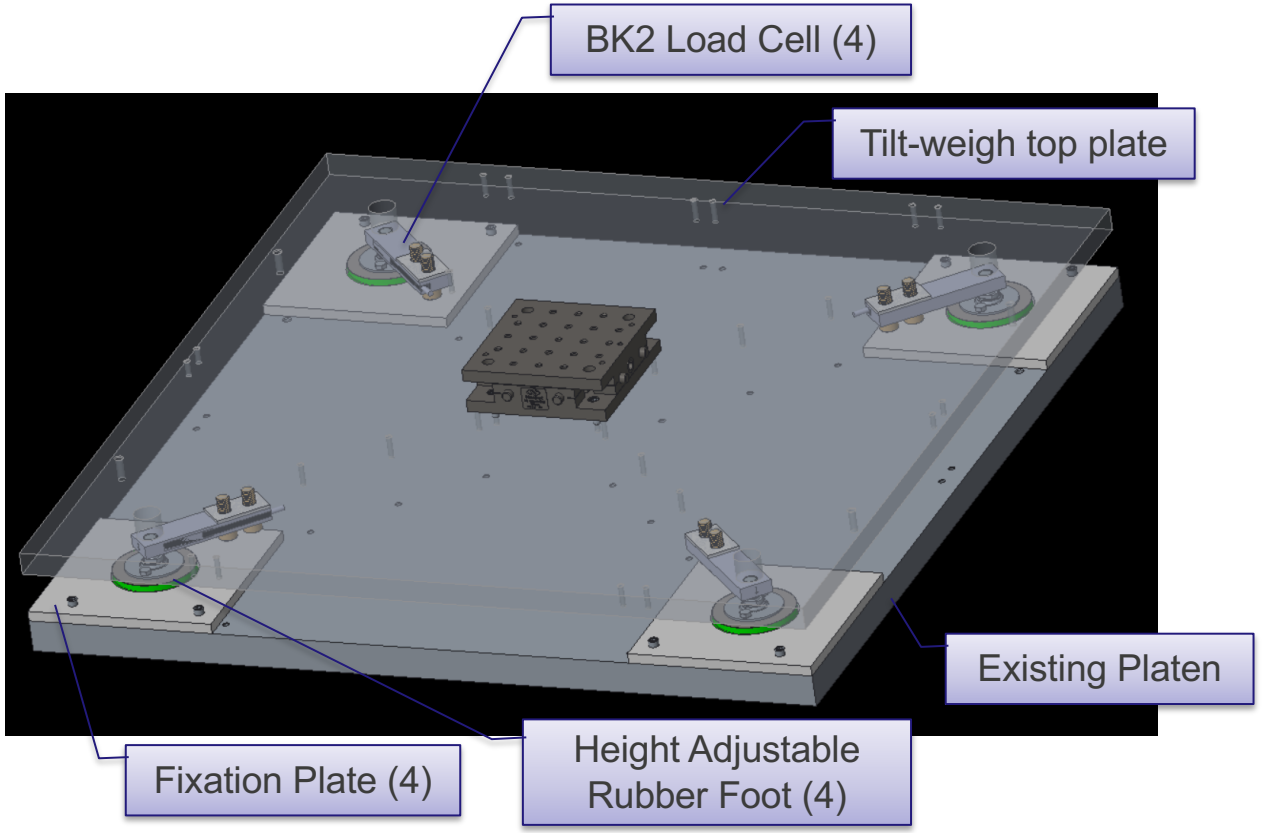
Tilt-weigh Platform



- Beam load cell with rubber foot and fixation plate on each corner. The pin on the rubber foot will be slotted and can be rotated with a screwdriver to adjust foot height.

Load Cell

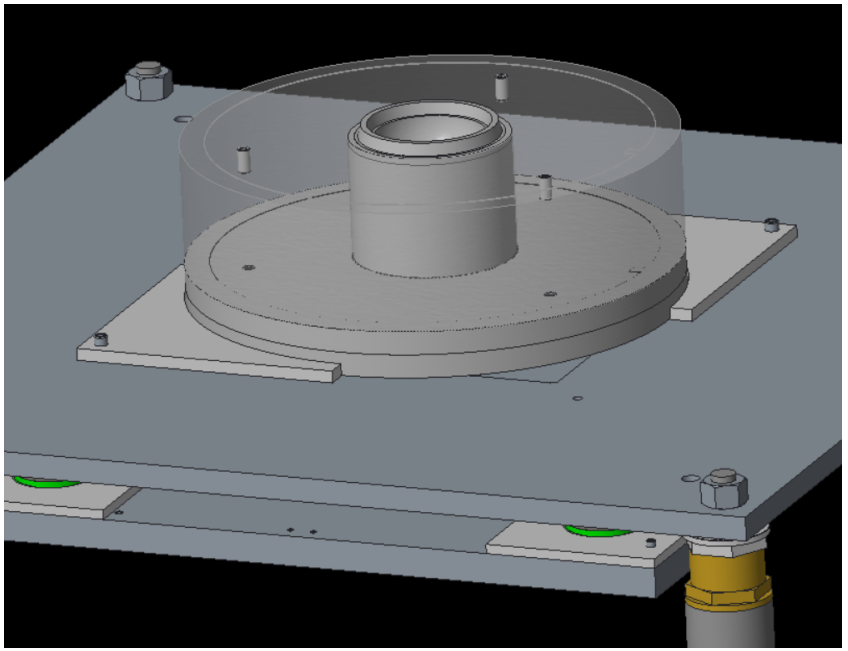
- Load cells at each corner are determine weight on plate
- This can be used to tell when the pedestal is seated and pressing on the reflector.
- Load limit
  - 1760 +/- 0.5 lbf



The tilt-weigh top plate is shown in transparent display.

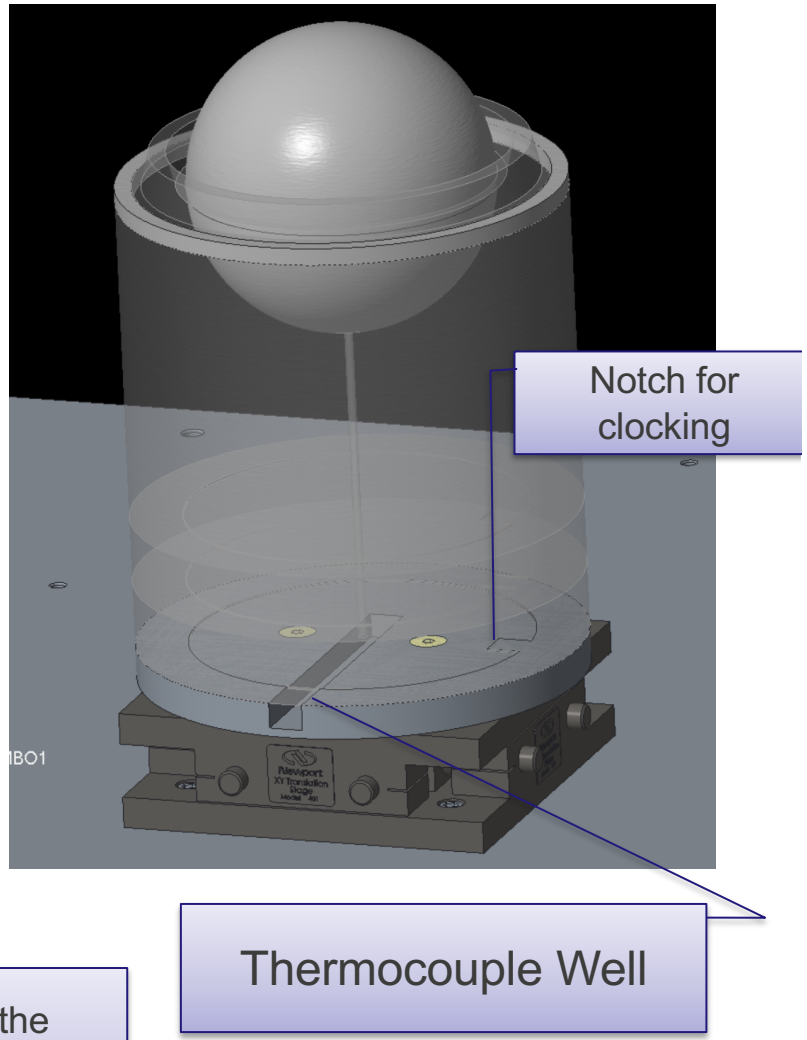
X-Y Table for Adjustment of Pedestal

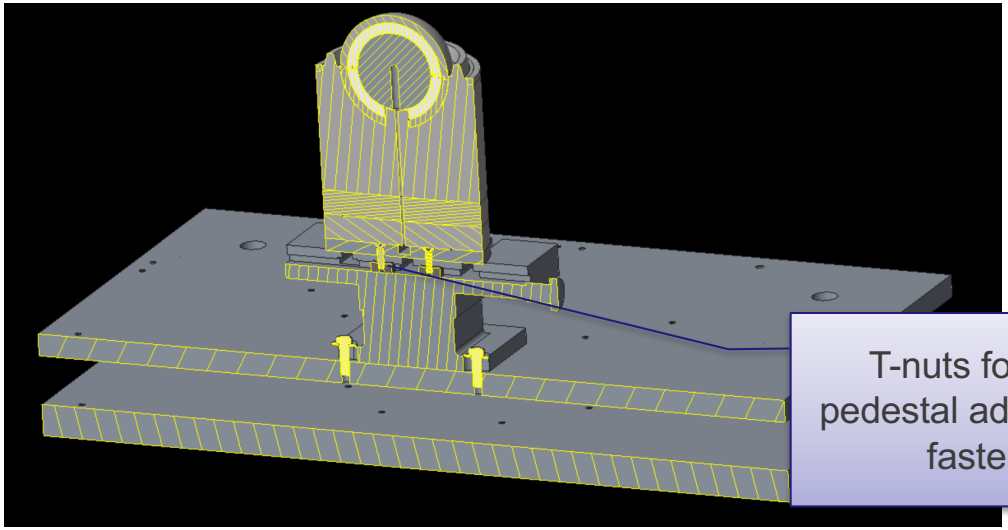
- Provides translation control for pedestal
- XY table attaches to the tilt-weigh platform
- 6” table width x 10” table length, 4.375 overall height
- With upper monolith removed, user can visually verify alignment by running the platen up with pedestal installed.
  - Make axis adjustments and repeat
- Table to be procured for the IER 488 (MUSiC) experiment



Pedestal Adapter Plate

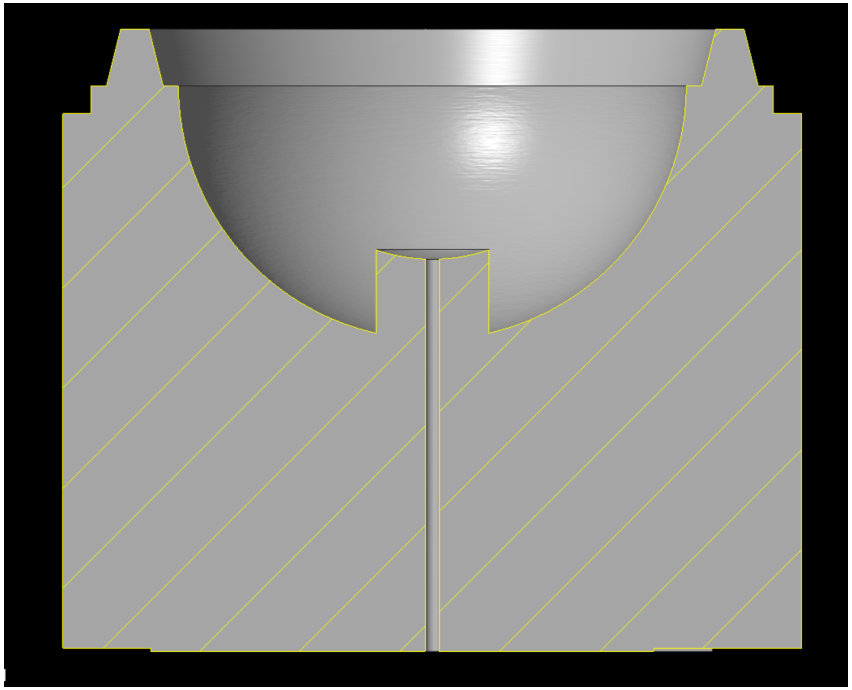
- Aluminum
- Pedestal mounts to a pedestal adapter plate on the XY Table
- Adapter plate attaches to X-Y table
- Provides path for thermocouple cable

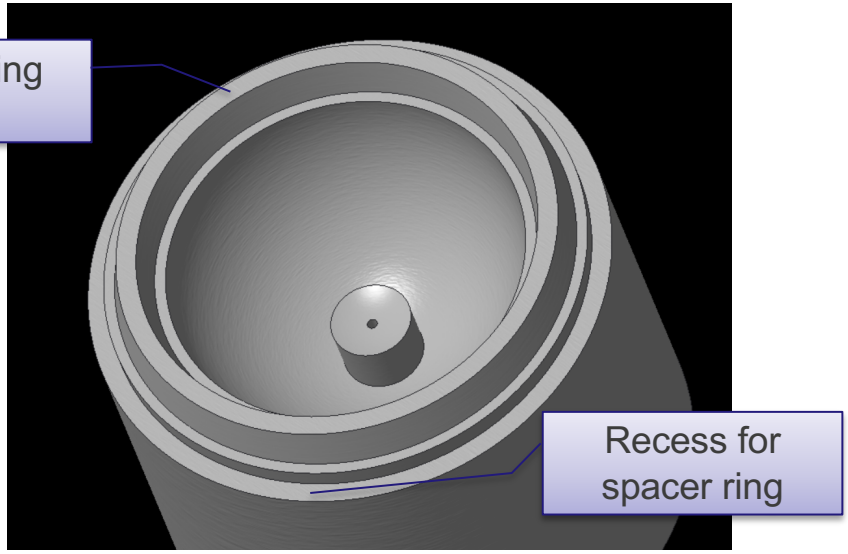


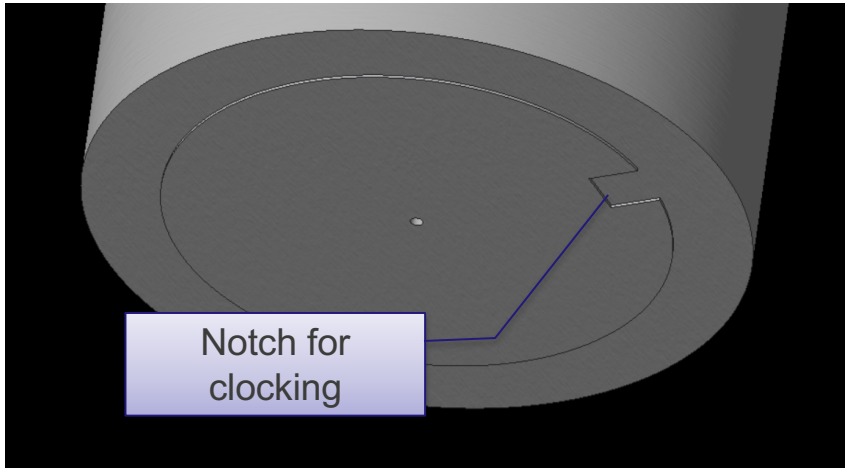


Pedestal will mount to a pec on the XY Table

Pedestal Features

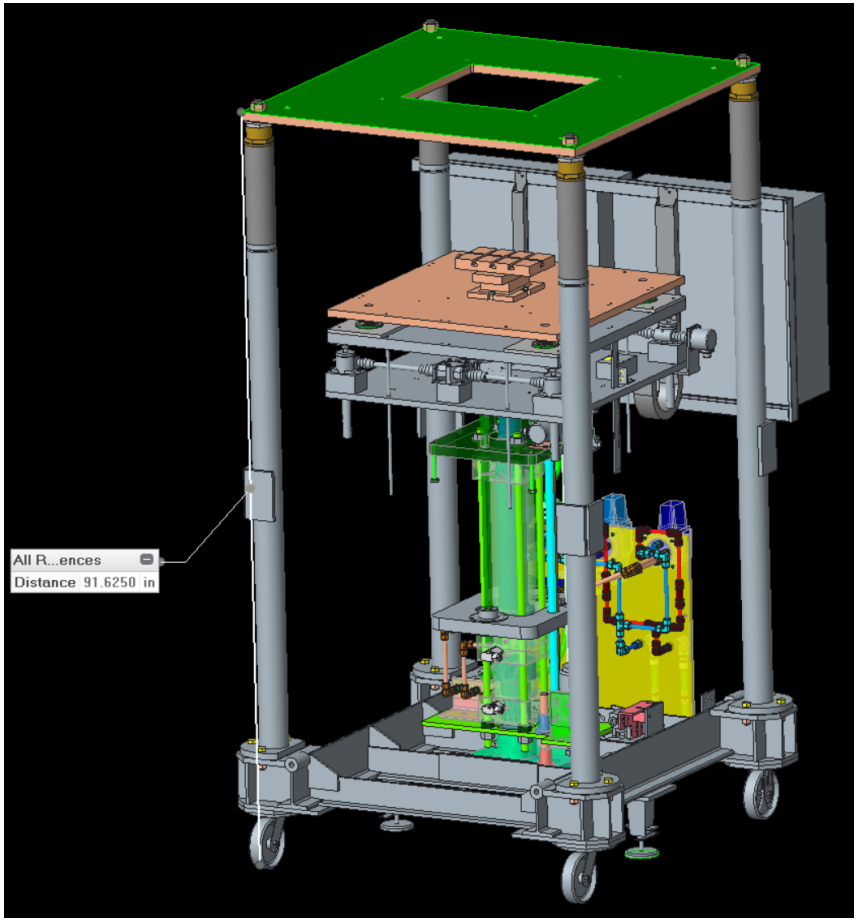






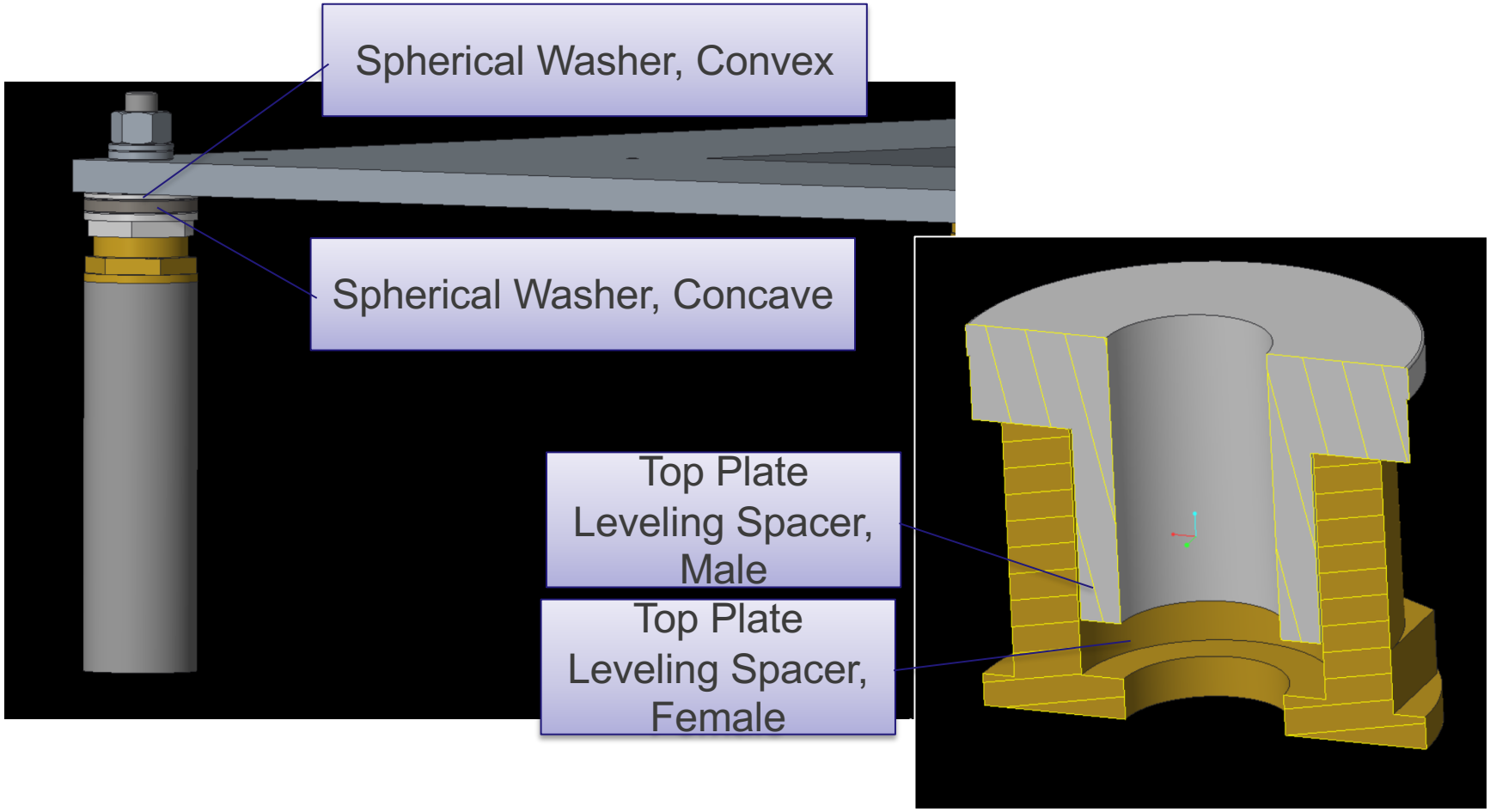
Column Extenders

- Leveling table, X-Y table, etc. take up space.
- Column extenders increase the distance between the moveable and stationary platforms.
- Extenders have been used on Planet in the past.
- New extenders will be built (safety-significant).
- Adds 15”
- Total drive distance to close is ~20”
- Room to work above pedestal is ~10 in.



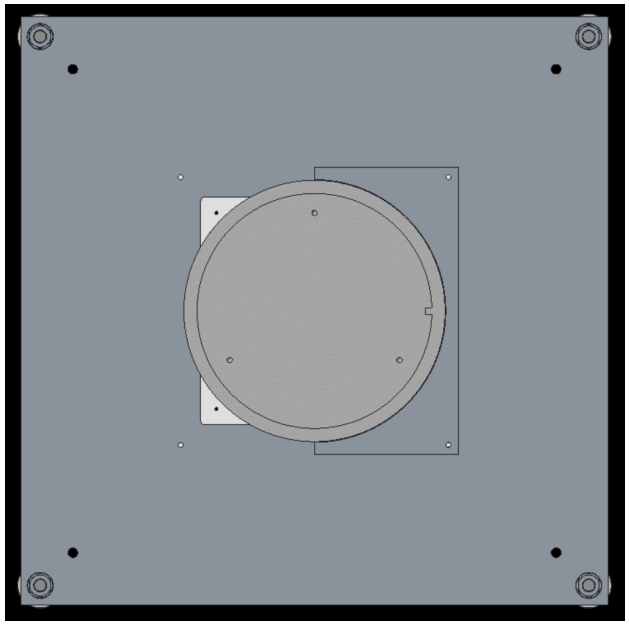
Adjustment of the Planet Upper Platform

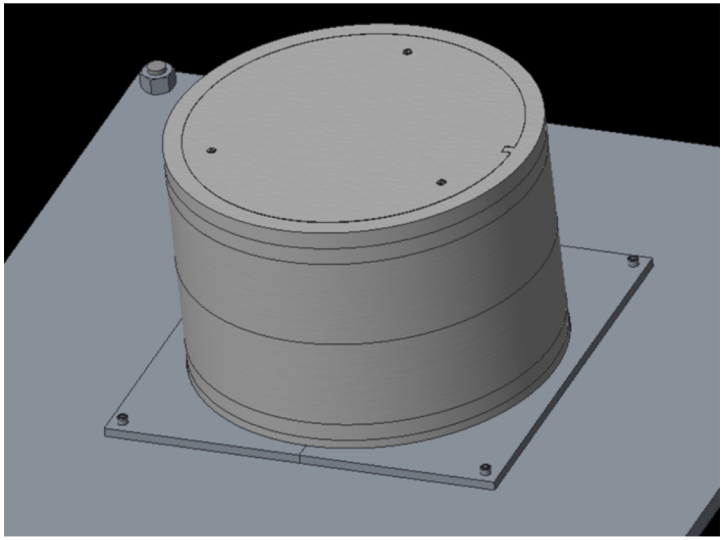
- Leveling spacers allow adjustment at each corner
- Threaded bushings with 2 inch ACME threads
- ACME for strength and prevents backdriving



Top Plate

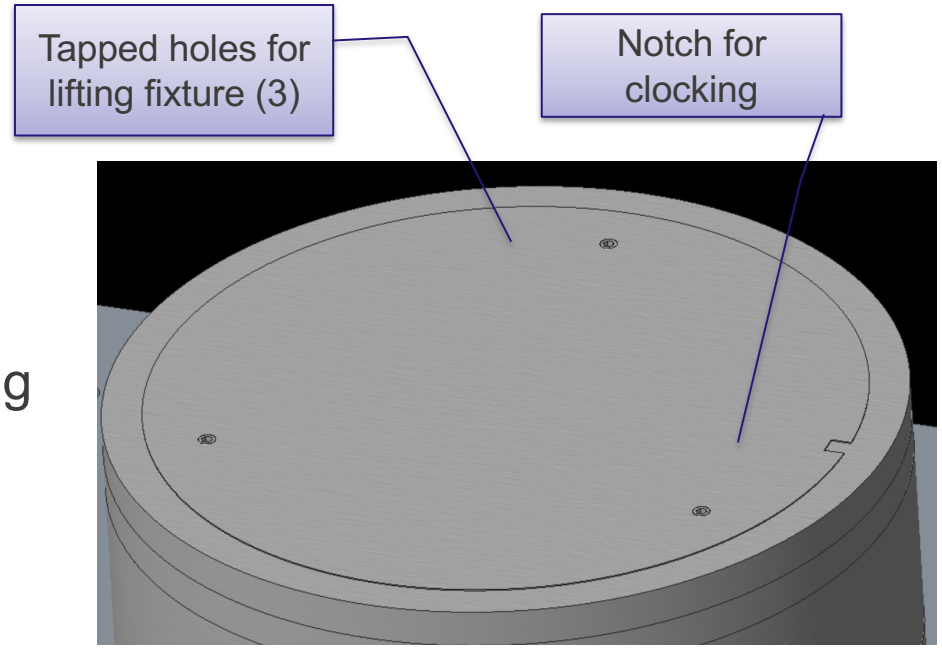
- Can use existing Planet Top Plate
  - 17.4” square opening
  - 2000 lbf permitted
- IER 203 weight above top plate is 1313 lbf.
- X-Y alignment plates surround the monolith to hold it in place.

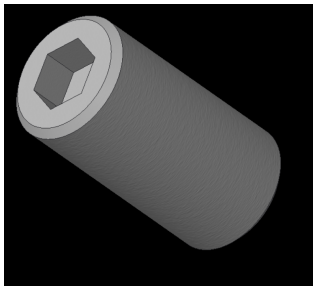




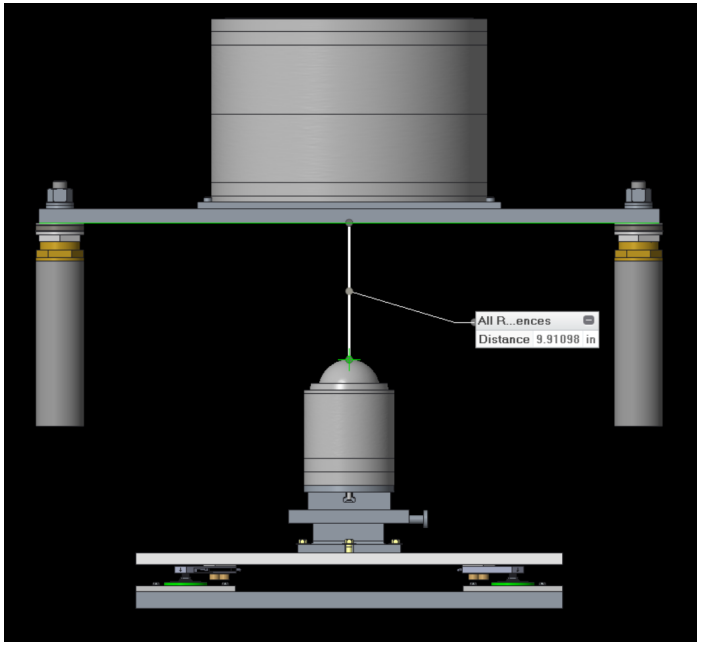
Reflector Features

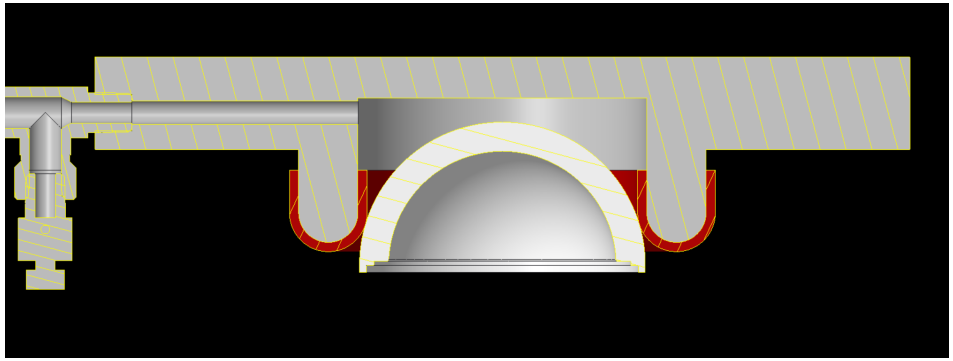
- All plates have step joint for stacking registration
  - Also have notch for clocking
- All plates have three holes for lifting fixture
  - Nickel threaded plugs installed after lift
- 1” upper plates weigh 97 lbf. Strongly considering handles.

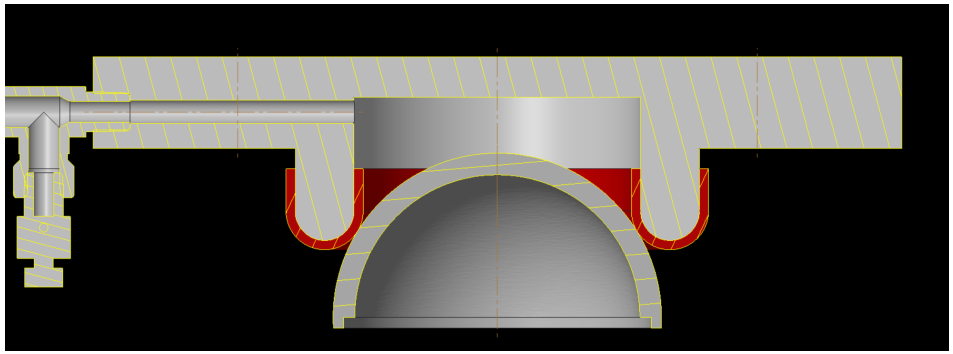




Design Features- Column Extensions cont.





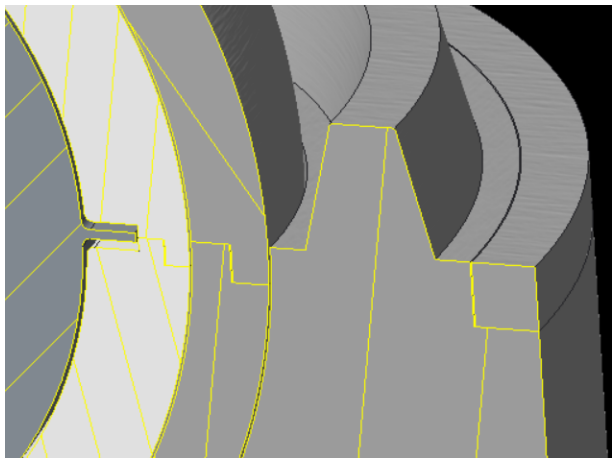


Room for vacuum chuck is ~10 in.

**Experiment is shown in fully retracted position*

Tolerances

- Prediction of gap between BeRP ball and shell above is .009-.016” if tolerances on the spherical radii of the shells is .003”.
- Shells modeled at their least material condition (LMC), center of pedestal at its highest and the reverse.
- Upon full closure, the self aligning feature on the pedestal, then the nickel shells, will be in compression before the BeRP ball.
- Ensure the BeRP ball will always rest on the pedestal, aiding heat transfer.
- Since .003” tolerance with HDPE is probably not realistic, test fitting will be needed.

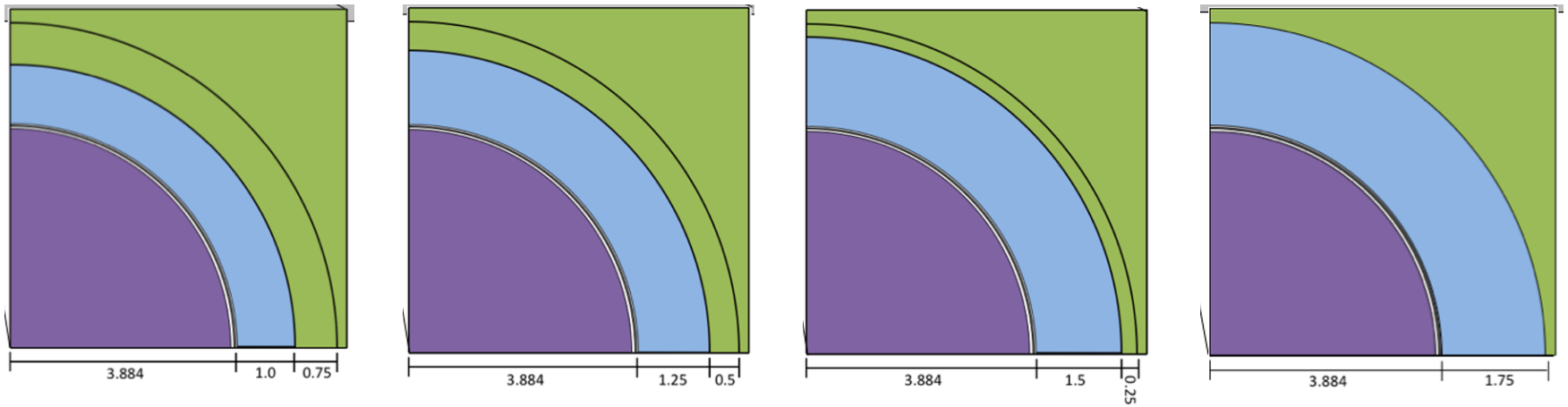


Procure and test fit on the bench with mock BeRP ball

Experimental Design Challenges

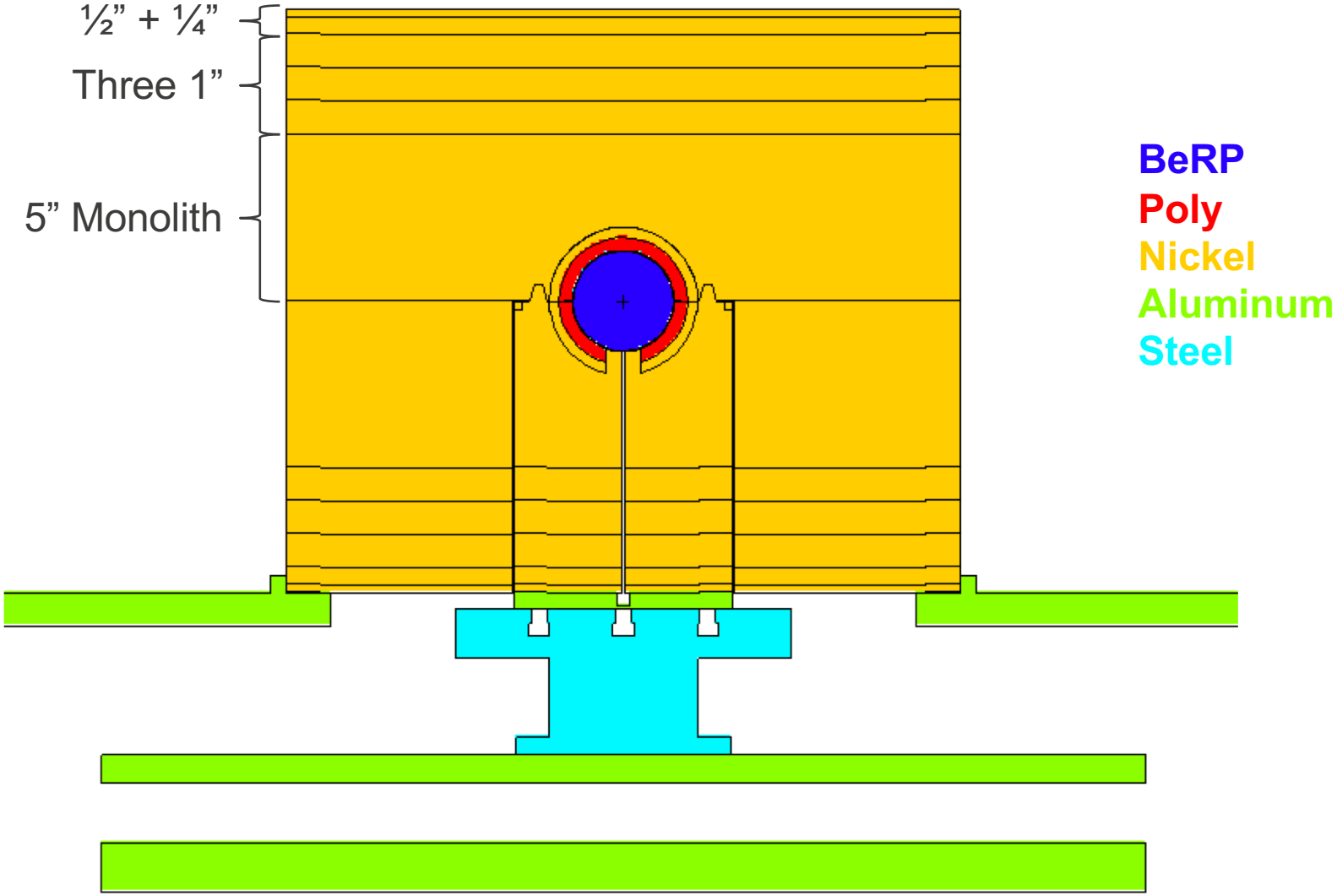
- Determine starting configurations for each case in experiment plan
- Determine initial separation distances for 1/M
- Range and distribution of spacers needed for approach to critical
- Range of thicknesses for additional nickel reflector plates
- Estimate reactivity insertion rate
- Sequence for assembly

Figure from LLNL revised CED-2 addendum



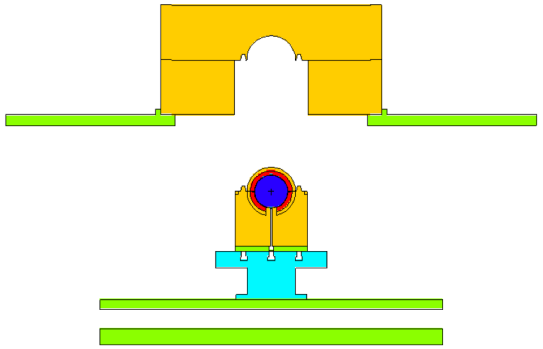
Case 1	*Case 2*	*Case 3*	*Case 4*
1 cm poly	1.25 cm poly	1.5 cm poly	1.75 cm poly
.75 cm nickel	.5 cm nickel	.25 cm nickel	0 cm nickel

MCNP Model Example (8.75” Thick Nickel)



Starting Configurations

- Full separation distance of 20”
- Includes presence of upper reflector monolith
- No extra nickel reflector plates for ease of comparison
- Hands are modeled very conservatively as 1” water

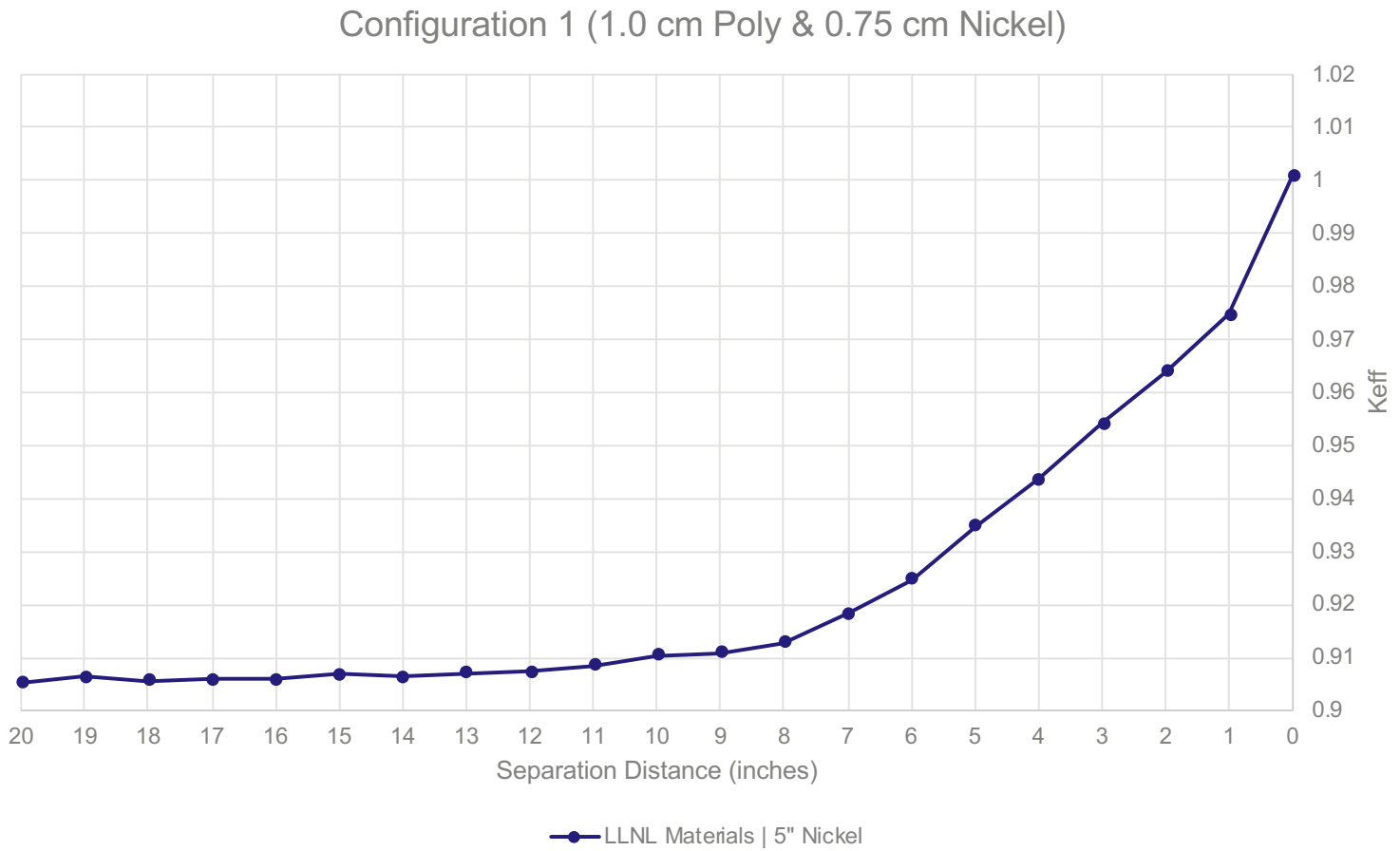


K_{eff} and Multiplication of Starting Configurations

	Base Case		w/ Vacuum Chuck		w/ Hands	
	keff(σ)	M	keff(σ)	M	keff(σ)	M
Case 1	0.90520(67)	10.55	0.91420(69)	11.66	0.92545(70)	13.41
Case 2	0.90515(63)	10.57	0.91528(62)	11.80	0.92657(73)	13.62
Case 3	0.90343(64)	10.36	0.91300(65)	11.50	0.92687(70)	13.67
Case 4	0.89852(69)	9.85	0.90857(65)	10.94	0.92687(73)	13.67

Initial Separation Distances

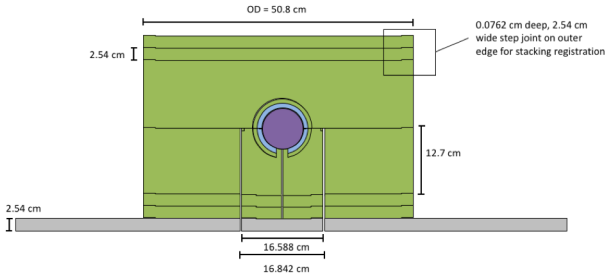
- No appreciable reactivity change before 12 inches separation
- 12 inches for first 1/M data point
- 8 inches for second 1/M data point

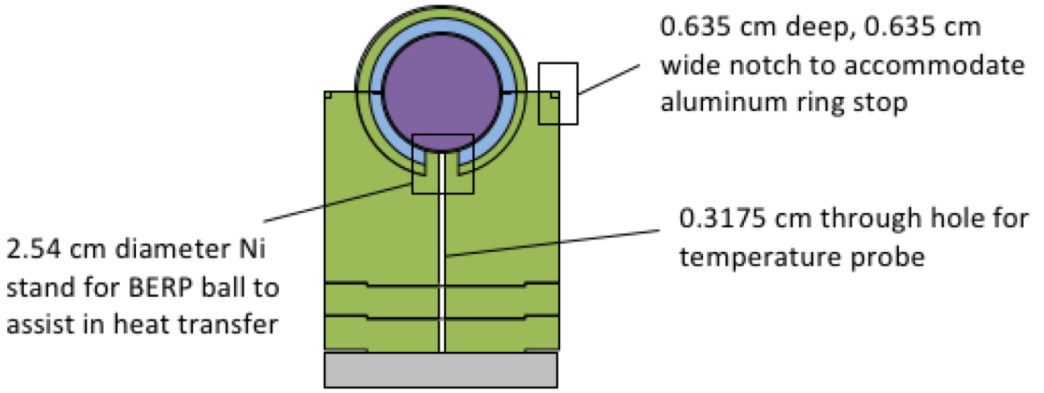


• Predicted Critical Configurations

- Additional nickel reflection added in the form of plates.
- Plates can be added to the top and/or bottom.
- Cases vary in number of plates needed.

Number	Thickness of PE Shell (cm)	Critical Ni Reflector Height, H (cm)	Number of 1" Ni Plates	Total Ni Weight (kg)	CED-2 Design k_{eff} (σ)
1	1	35.56	4	636.73	1.00001(34)
2	1.25	30.48	2	544.39	1.00112(35)
3	1.5	27.94	1	497.78	1.00069(36)
4	1.75	30.48	2	542.72	1.00110(37)



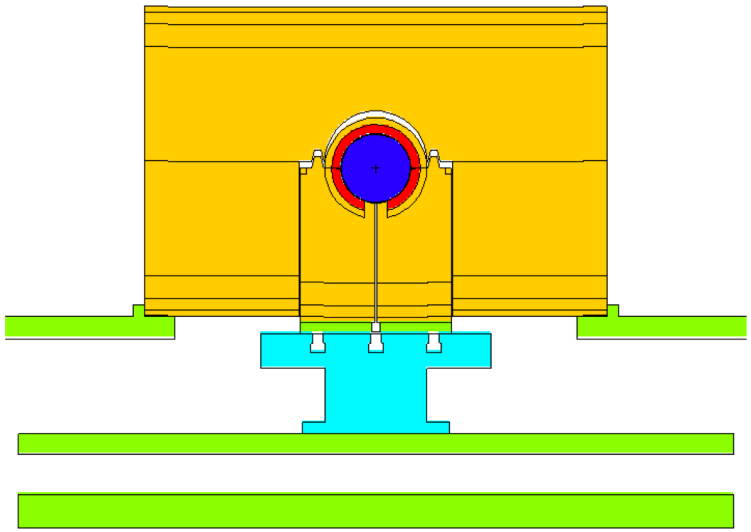


Figures and Table from LLNL revised CED-2 addendum

Reactivity Worth of Additional Plates

- Case 1: 1.00 cm Poly & 0.75 cm Nickel;
  - ¼” Plate: +0.00078 or $0.39
  - ½” Plate: +0.00178 or $0.89
  - ¾” Plate: +0.00326 or $1.63
  - 1” Plate: +0.00329 or $1.65 → $0.80/inch
- Case 2: 1.25 cm Poly & 0.50 cm Nickel;
  - ¼” Plate: +0.00205 or $1.025
  - ½” Plate: +0.00171 or $0.855
  - ¾” Plate: +0.00318 or $1.590
  - 1” Plate: +0.00377 or $1.885
- Case 3: 1.50 cm Poly & 0.25 cm Nickel;
  - ¼” Plate: +0.00011 or $0.055
  - ½” Plate: +0.00071 or $0.355
  - ¾” Plate: +0.00202 or $1.010
  - 1” Plate: +0.00305 or $1.525
- Case 4: 1.75 cm Poly;
  - ¼” Plate: +0.00231 or $1.155
  - ½” Plate: +0.00283 or $1.415
  - ¾” Plate: +0.00214 or $1.070
  - 1” Plate: +0.00531 or $2.655

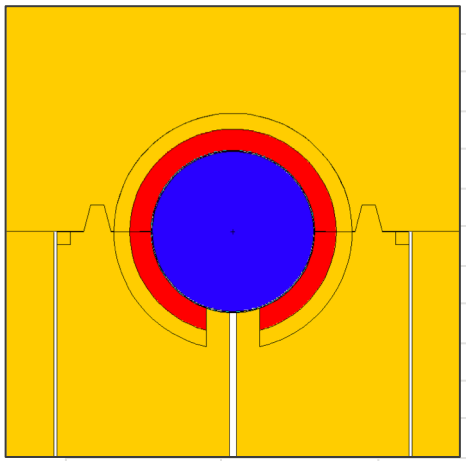
Results are for symmetric addition to top and bottom. Divide by 2 to estimate worth per plate.



½” and ¼” nickel plates are indeed needed for finer reactivity control

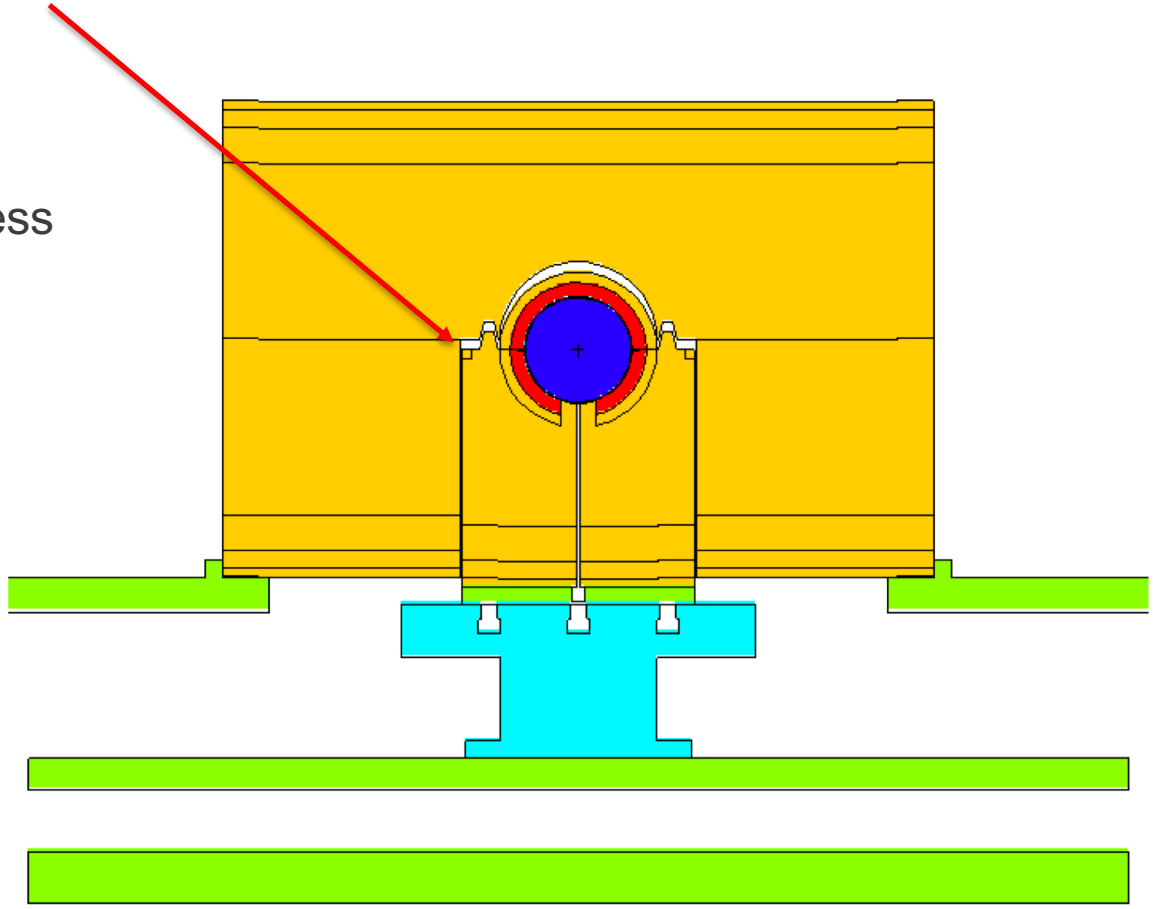
Reactivity Rate Near Closure

~1.0-1.5 cent/mil



Sizes of Spacer Rings

Fit in groove on pedestal
Used to maintain known separation and control excess reactivity



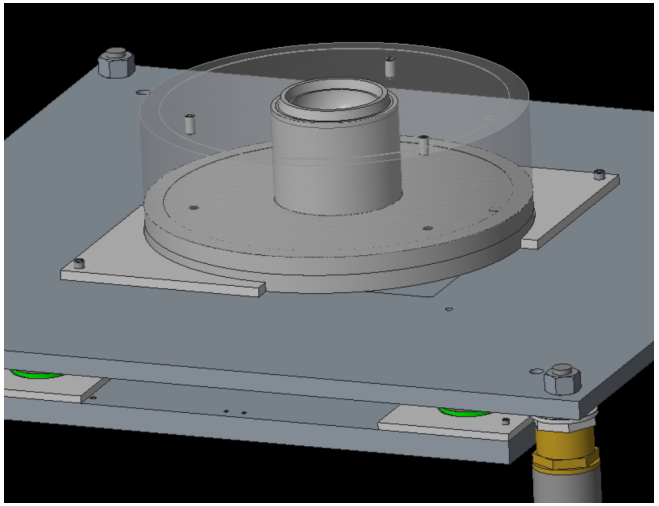
From previous slide
Reactivity worth is
1.0-1.5 cent/mil

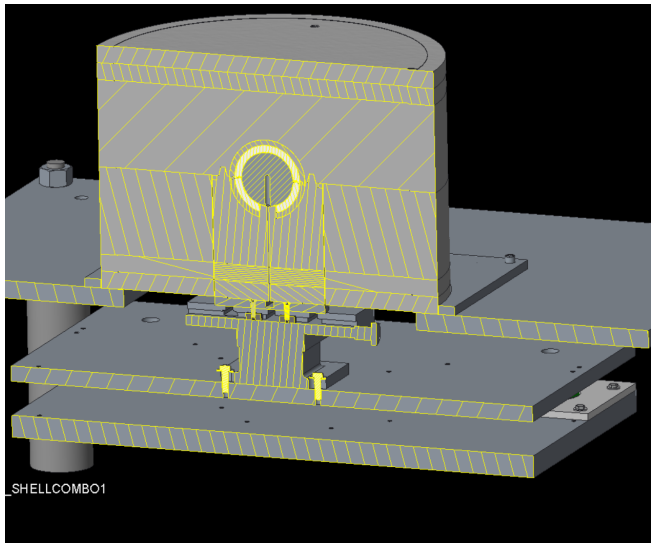
Proposed

- 10 mil spacer
- 20 mil spacer
- 50 mil to 300 mils in 50 mil increments
- 500 mil spacer

Assembly Sequence

- Install base of monolith
- Install empty pedestal
- Operate in *Local* to align and center
- Load upper portion of monolith
- Operate in *Local* to test load cell
- Load lower shells, then BeRP ball, then use a vacuum chuck to load upper shells
- Place spacer ring
- Operate in *Remote*, performing Approach-to-Critical on separation
- Change spacer ring as indicated
- Repeat as needed until no spacer
- Add nickel plates to top of monolith
- Swap top nickel plates for nickel plates on the bottom – requires complete defueling
- Operate in *Remote*
- Add nickel plates to top as needed
- Find critical configuration <80 cents





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